IN THE UNITED STATES PATENT AND TRADEMARK OFFICE
BEFORE THE BOARD OF PATENT APPEALS AND INTERFERENCES

Appeal No:

In re the Application of: **Kozo SHIMIZU et al.**

Group Art Unit: **1742**

Serial No.: **09/731,726**

Examiner: **Sikyin Ip**

Filed: **December 8, 2000**

P.T.O. Confirmation No.: 1555

#11

For: **A SOLDER ALLOY, A CIRCUIT SUBSTRATE, A SEMICONDUCTOR DEVICE AND A METHOD OF MANUFACTURING THE SAME**

RO 06/10/03

BRIEF ON APPEAL

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

June 5, 2003

Sir:

I. REAL PARTY IN INTEREST

The real party in interest is the assignee, Fujitsu Limited, as evidenced by the assignment recorded on December 8, 2000, in reel 011350, frame 0194.

II. RELATED APPEALS AND INTERFERENCES

Appellants know of no other appeals or interferences which will directly affect, be directly affected by, or have a bearing on the Board's decision in this appeal.

III. STATUS OF CLAIMS

Claims 1-6, 15 and 16 are pending in this application. Claims 1-16 have been presented in this application, with claims 7-14 cancelled without prejudice or disclaimer in the Amendment under 37 CFR 1.116 dated March 6, 2003. Claims 1-6, 15 and 16 stand rejected and are the subject of this appeal.

IV. STATUS OF AMENDMENTS

Claims 7-14 were cancelled in the Amendment under 37 CFR 1.116 dated March 6, 2003. In the Advisory action dated March 18, 2003, it was indicated that this amendment would be entered upon filing an appeal.

V. SUMMARY OF THE INVENTION

Claim 1 recites a semiconductor device comprising a circuit substrate, a semiconductor element and a bump made of a solder alloy, through which the semiconductor element is bonded onto the circuit substrate. The present specification discusses flip chip bonding on page 1 and page 1, third paragraph, indicates that, in flip chip bonding, a semiconductor element and a substrate are bonded directly through a solder bump.

Claim 1 further recites a limitation on the composition of the solder alloy. The solder alloy is an Sn-Ag-based alloy, has 90 (wt%) or more Sn content, the Ag content is 1.5 (wt%) to 2.8 (wt%), and the amount of α-rays in Sn is 0.01 cph/cm^2 or less. These limitations are supported by the specification on page 5, lines 5-8; page 5, line 28, to page 6, line 6; page 7, lines 6-14; and page 10, line 27, to page 11, line 2.

Claim 2 depends from claim 1, limiting the device to have the semiconductor element connected to the circuit substrate through 1,000 or more terminals each made of a bump (see specification on page 5, lines 16-18).

Claim 3 depends from claim 1, limiting the solder alloy to further contain at least one of Cu, Zn, In, Sb and Bi (see specification on page 5, line 12-15).

Claim 4 is independent and recites a circuit substrate comprising elements bonded thereon through bumps made of a solder alloy. (See page 5, lines 19-24, of the specification). Claim 4 further recites a limitation on the composition of the solder alloy. The solder alloy is an Sn-Ag-based alloy, has 90 (wt%) or more Sn content, the Ag content is 1.5 (wt%) to 2.8 (wt%), and the amount of α-rays in Sn is 0.01 cph/cm^2 or less. Particular support for the composition limitation may also be found on page 5, line 28, to page 6, line 6; page 7, lines 6-14; and page 10, line 27, to page 11, line 2.

Claim 5 depends from claim 4, limiting the device to have the semiconductor element connected to the circuit substrate through 1,000 or more terminals each made of a bump (see specification on page 5, lines 16-18).

Claim 6 depends from claim 4, limiting the solder alloy to further contain at least one of Cu, Zn, In, Sb and Bi (see specification on page 5, line 12-15).

Claim 15 depends from claim 1, further limiting the solder alloy to be made from Sn prepared using a zone-melt method. Claim 16 depends from claim 4 with the same further limitation. Support for these claims may be found in the specification on page 12, line 20, to page 13, line 2.

VI. ISSUES

A. Whether claims 1-6 are unpatentable under 35 U.S.C. 103(a) over PL 115725 (Kozlowski et al.), JP 2000015476 (Matsumoto et al.), Arai et al. (1999 article), or Ogashiwa et al. (U.S. Patent No. 6,160,224) in view of JP 409260427 (Akamatsu et al.).

B. Whether claims 15 and 16 are unpatentable under 35 U.S.C. 103(a) over PL 115725 (Kozlowski et al.), JP 2000015476 (Matsumoto et al.), Arai et al. (1999 article), or Ogashiwa et al. (U.S. Patent No. 6,160,224) in view of JP 409260427 (Akamatsu et al.), and further in view of Bult et al. (U.S. Patent No. 4,690,725).

VII. GROUPING OF THE CLAIMS

For purposed of appeal the claims stand or fall together.

VIII. ARGUMENTS

Issue A. Whether claims 1-6 are unpatentable under 35 U.S.C. 103(a) over PL 115725 (Kozlowski et al.), JP 2000015476 (Matsumoto et al.), Arai et al. (1999 article), or Ogashiwa et al. (U.S. Patent No. 6,160,224) in view of JP 409260427 (Akamatsu et al.).

The main issue in this rejection is whether a *prima facie* case of obviousness can be made for the present claims by taking the cited references in combination. Specifically at issue is whether the references, taken in combination, suggest or motivate the specific combination of limitations on the solder alloy recited in the claims.

a. Summary of the teachings of the references

As an aid in the presentation of Appellants' arguments, Appellants here summarize the relevant teachings of the cited references with regard to the present claims.

PL 115725 (Kozlowski et al.) (Abstract). This reference discloses an alloy composition for ohmic contacts having 0.1-5 wt% In or Ga, and 0.1-20 wt% Ag, Au or Pt, in 75-99.7 wt% Sn. There is no disclosure regarding the α-ray content.

JP 2000015476 (Matsumoto et al.) (Abstract). This reference discloses solders for mounting semiconductor chips on substrates. These are Sn alloys containing 0.3-3.5 wt% Ag; 0.5-10.0 wt% Bi; 0.1-1.0 wt% Cu; 0.001-0.01 wt% P; and microalloyed with (a) 0.001-0.01 wt% Ni, (b) 0.005-0.05 wt% Ge; (c) 0.001-0.01 wt% Te; and 0.01-0.1 wt% Ga, or (d) 0.001-0.01 wt% Co and/or 0.005-0.05 wt% Cr. There is no disclosure regarding the α-ray content.

Arai et al. (1999 article) (Abstract). This reference discloses Sn-Ag-Cu solder bumps for flip-chip bonding, formed using electroplating. The electrodeposited films contained 2-9 atom-% Ag and 2-11 atom-% Cu. (Appellants note that the wt% range of Ag implied by the disclosed atom-% range is dependent upon the amount of Cu present. Appellants calculate the maximum possible wt% range of Ag to be 1.8 to 8.7 wt%, and of Sn to be 86.2 to 97.1 wt%, in the disclosed compositions). There is no disclosure regarding the α-ray content.

Ogashiwa et al. (U.S. Patent No. 6,160,224). This reference discloses a solder material for joining an electronic component to a substrate. Solder balls are made of the solder material containing 0.01 to 4.99 wt% Fe; 0.01 to 4.99 wt% Ni, with total of Fe plus Ni being 0.02 to 5.0 wt %; 0.1 to 8.0 wt% of at least one of Ag and In; from 0 to 70 wt% of Pb; balance containing Sn and unavoidable impurity. Twenty embodiments of the invention are disclosed, summarized in Table 1 in column 7.

Appellants note that in these twenty embodiments, the Ag content ranges from 0 to 6.00 wt%. However, **none** of these embodiments has Ag in the range of 1.5 to 2.8 wt%. The Sn range is presented as the "balance", but can be calculated to be from 18% to 96% in the embodiments. Only embodiments 12, 13, 17 and 20 have Sn values in the range of 90% or more.

JP 409260427 (Akamatsu et al.) This reference discloses solder bump formed on a pad of a semiconductor substrate by a plating method. The solder alloy is an alloy of Sn and Bi or an element having an atomic number smaller than 81 and not related with α-decay. In the table on page 5 of the reference, examples 1-16 are given. In these examples, the third column indicates that α-rays are "<0.1 cph/cm^2".

Appellants note that some of these examples have 90% or more Sn (examples 1-4, 6-9, 11-14 and 16), and some of these examples have 1.5 to 2.8%Ag (examples 5k 10, and 15), but **none** of the examples has both 90% or more Sn and 1.5 to 2.8% Ag.

1. Errors in the rejection

a. First error. In the final Office action of November 6, 2002, the rejection is stated in paragraphs 4 and 5. In paragraph 5, the Examiner states: "The difference between the references and the claims are as follows: PL 115725, JP2000015476, Arai et al. and Ogashiwa et al. do not disclose the alpha ray in Sn. ..." Appellants respectfully submit that this constitutes a first **error** in the rejection. In fact, there are **additional differences** between these references and the present claims.

As can be seen from the above summaries of the references, **none** of the references appears to **teach** the specifically recited combination of wt% range limitations on Ag and Sn recited in all of the present claims (Sn is 90 wt% or more; Ag is 1.5 to 2.8 wt%). The Examiner **does not**

specifically address the issue of whether this combination of limitations is **suggested** by the references. Applicants address this issue below.

PL 115725 (Kozlowski et al.) discloses an alloy composition for ohmic contacts having 0.1-5 wt% In or Ga, and 0.1-20 wt% Ag, Au or Pt, in 75-99.7 wt% Sn. The reference requires Ag, Au or Pt, but this is not a requirement for Ag. That is, the disclosure encompasses a large number of possible alloys, only some of which have Ag. When Ag is used, the reference discloses a range of 0.1-20 wt%; this range is much broader than the recited range of 1.5 to 2.8% (approx. 15 times as broad). The disclosed Sn content in the reference, 75-99.7%, is considerably broader than the recited range of 90% or more. Applicants submit that the disclosure of Kozlowski et al. is too broad to suggest the limitations on the amounts of Ag and Sn of the present claims.

JP 2000015476 (Matsumoto et al.) discloses Sn alloys containing 0.3-3.5 wt% Ag; 0.5-10.0 wt% Bi; 0.1-1.0 wt% Cu; 0.001-0.01 wt% P; and microalloyed with (a) 0.001-0.01 wt% Ni, (b) 0.005-0.05 wt% Ge; (c) 0.001-0.01 wt% Te; and 0.01-0.1 wt% Ga, or (d) 0.001-0.01 wt% Co and/or 0.005-0.05 wt% Cr. Presumably, the Sn is the remainder, and therefore would be greater than about 84.5%. Although there is overlap of the claimed Ag and Sn contents with portions of the disclosed ranges, there is no direct suggestion in the reference for the claimed combination of limitations.

Arai et al. (1999 article) discloses a Sn-Ag-Cu solder in which Appellants calculate the maximum possible wt% range of Ag to be 1.8 to 8.7 wt%, and of Sn to be 86.2 to 97.1 wt%. The disclosed Ag and Sn ranges are thus considerably broader than the claimed Ag and Sn ranges of the present claims.

Ogashiwa et al. (U.S. Patent No. 6,160,224) discloses a solder material containing 0.01 to 4.99 wt% Fe; 0.01 to 4.99 wt% Ni, with total of Fe plus Ni being 0.02 to 5.0 wt %; 0.1 to 8.0 wt%

of at least one of Ag and In; from 0 to 70 wt% of Pb; balance containing Sn and unavoidable impurity. As Appellants have noted, twenty embodiments of the invention are disclosed, summarized in Table 1 in column 7. However, **none** of these embodiments has Ag in the recited range of 1.5 to 2.8 wt%. Only four of the embodiments have Sn values in the range of 90% or more. Therefore, **none** of the embodiments suggests the recited Ag range, and none of the embodiments meets the Ag and Sn limitations of the present claims. Appellants submit that Ogashiwa et al. cannot be taken as suggesting the Ag and Sn limitations of the present claims.

Appellants therefore contend that PL 115725 (Kozlowski et al.) and Ogashiwa et al.'224 cannot be considered at all to suggest the combination of Ag and Sn wt% limitations of the present claims. JP 2000015476 (Matsumoto et al.) and Arai et al. (1999 article) might be taken to suggest the combination of Ag and Sn ranges **only** in that the individual ranges disclosed in the references for Ag and Sn overlap the claimed ranges. However, Appellants submit that these references do not, in fact, provide a proper suggestion for the recited **combination** of limitations. It is well known in the art that the properties inferred by the components in an alloy are not simply additive, but that there may be interactions of the properties. That is, the recited specific combination of two range limitations does not merely represent narrowing of a single disclosed range.

The Examiner had cited *In re Wertheim* in the final Office action (paragraph 10), stating that: "overlapping ranges have been held to be a prima facie case of obviousness." Appellants had noted in the Response dated March 6, 2003, that this was correct, but Appellants submit that this refers to a claim differing from the prior art in a **single** range limitation, not in a **combination** of range limitations. In addition, in the final Office action and in the Advisory action dated March 18, 2003, the Examiner cites another portion of *In re Wertheim*, that "the disclosure in the prior art of any value

within a claimed range is an anticipation of that range." However, Appellants submit that this citation of *In re Wertheim* is directed to **anticipation** of the claim, and is not relevant to the present rejection. In fact, none of the prior art reference discloses an example having both Ag and Sn values within the ranges recited in the present claims; that is, there is no example meeting those two limitations of the present claims, and clearly there is no example meeting the Ag and Sn limitations as well as the α ray limitation.

b. Second error. In the final Office action of November 6, 2002, paragraph 5, the Examiner goes on to state: "However, JP 409260427 in abstract and Table 1 in col. 7 disclose(s) alpha ray could be reduced from a solder bump in the same field of endeavor or the analogous metallurgical art. Therefore, it would have been obvious to one having ordinary skill in the art ... to reduce alpha rays from a solder bump as taught by JP 409260427 in order to eliminate soft error inversion ratio of semiconductor device."

Appellants interpret this statement as a combination of one of the solders of PL 115725 (Kozlowski et al.), JP 2000015476 (Matsumoto et al.), Arai et al. (1999 article), or Ogashiwa et al. (U.S. Patent No. 6,160,224) with the teaching of JP '427 inferred from the values of <0.1 cph/cm^2 in Table 1. However, Appellants submit that the teaching of JP'427 is for a solder which has no element above 81, in particular, no Pb. However, Ogashiwa et al. '224, although not requiring Pb, definitely suggests Pb, with Pb being present in 11 of the 20 embodiments in the reference. That is, in order to combine the teachings of Ogashiwa '224 with JP'427, one must add the additional limitation of "no Pb" to Ogashiwa et al. Applicants submit that there is therefore no suggestion or motivation to combine Ogashiwa '224 with JP'427.

c. <u>Third error.</u> As noted above, the rejection is based on the listed value for α rays in Table 1 of JP'427, which states "<0.1 cph/cm^2". However, the present claims all require the amount of α rays to be 0.01 (cph/cm^2) or less. The maximum value in this range is fully 10 times less than the maximum value in the disclosed range. This point is addressed only in the Response to Arguments in paragraph 12 of the final Office action. The Examiner states "Although said reference does not disclose the alpha ray concentration, the goal is the same as instant invention of reduce it to zero in order reduce the soft error inversion ratio of a semiconductor device. It is well settled that the difference in degree of purity itself (here alpha ray concentration) does not predicate invention. In re Merz, 38 USPQ 143 and In re King et al. 43 USPQ 400)." Appellants respectfully submit that this line of argument represents a **third error** in the rejection.

In *In re Merz*, the applicant was "not entitled to a patent on an article which after being produced has greater degree of purity than product of former methods". However, Appellants submit that the pending claims do **not** merely differ from the cited references in having a lower upper limit for the α ray limitation. As noted above, **none** of the references, in particular Akamatsu, teaches the combination of limitations on amount of Ag and Sn of the present claims.

Moreover, Appellants note in this regard that MPEP 2142 provides:

> "To establish a prima facie case of obviousness, three basic criteria must be met. First, there must be some suggestion or motivation, either in the references themselves or in the knowledge generally available to one of ordinary skill in the art, to modify the reference or to combine reference teachings. Second, there must be a reasonable expectation of success. **Finally, the prior art reference (or references when combined) must teach or suggest all the claim limitations. The teaching or suggestion to make the claimed combination and the reasonable expectation of success must be found in the prior art**, and not based on applicant's disclosure." (Emphasis added).

Akamatsu appears to indicate that values of <0.1 cph/cm^2 are adequate. Clearly, considerable additional effort in preparation of the solder is necessary to achieve a 10-fold lower upper limit on the value of α rays, and one of skill in the art would not be motivated by the teaching of Akamatsu to have values ten-fold lower than 0.1 cph/cm^2. Appellants argue that there is **no suggestion or motivation** in the Akamatsu reference for the specifically recited limitation to a value of 0.01 (cph/cm^2) or less.

2. The specific limitations in the rejected claims which are not described in the prior art, and how such limitations render the claimed subject matter unobvious over the prior art.

Appellants have argued above that the PL 115725 (Kozlowski et al.) and Ogashiwa et al.'224 references cannot be considered to suggest the combination of Ag and Sn wt% limitations recited in the present claims. In addition, Appellants have argued that Ogashiwa cannot be combined with JP '427 due to the suggestion for Pb in Ogashiwa et al. '224.

In order to combine JP 2000015476 (Matsumoto et al.) or Arai et al. (1999 article) with JP 409260427 (Akamatsu et al.), it is necessary to produce the recitation of the present claims, it is necessary to take references as suggesting **three** separate limitations of the present claims that are not specifically taught in the references. Appellants summarize the teachings of these references as follows:

First of all, the present claims require 1.5 to 2.8% Ag. Matsumoto JP '476 teaches 0.3-3.5 wt% Ag and Arai et al. teaches 1.8 to 8.7 wt% Ag. Akamatsu JP'427 does not require Ag, and only a few of the given examples meet the recited limitation.

Secondly, the present claims require 90% or more Sn. Matsumoto JP'476 does not specifically disclose the amount of Sn. A range of greater than 84.5% can be inferred. Arai et al. does not specifically disclose the range of Sn. A range of 86.2 to 87.1 wt% can be inferred. The range of Sn in Akamatsu JP '427 is unclear, but examples range from 88-96.5%.

However, **none** of these references discloses an example meeting both the Ag and Sn limitations.

Only Akamatsu JP'427 discusses the amount of α rays. However, this reference only discloses examples of "<0.1 cph/cm^2". There is no teaching of using values of 0.01 cph/cm^2 or less. A suggestion for the recited reference comes only from the fact that the recited range of 0.01 cph/cm^2 or less is encompassed by "<0.1 cph/cm^2".

Appellants therefore argue that there is no suggestion in the cited references for the combination of the three limitations on Ag, Sn and α ray. Accordingly, no *prima facie* case of obviousness can be made for the claims under appeal using the cited references.

Moreover, even if the references were considered to provide the combination of limitations on Ag, Sn and α ray, Appellants submit that the result of this specific combination of limitations leads to results which are unexpected over the cited references.

For example, the specification discusses a specific reason for the Ag content upper limit of 2.8% on page 7, lines 6-14, related to the reaction of Sn with Au, Ni and Cu to form a metal compound. There is no discussion of this phenomenon in the cited references, and therefore, this limitation in itself leads to an unexpected result.

Similarly, the specification discusses problems resulting from Ag values of less than 1.5 wt% on page 8, lines 15-22, relating to transformation from β-Sn to α-Sn. There is no discussion of this phenomenon in the references.

In particular, Appellants note that the combination of **all three** of the recited limitations leads to results unexpected based on the cited references. It can be inferred from the present specification on page 7, line 25, to page 8, line 12, that the **particular combination** of recited limitations results in a specific effect. The specification indicates that even if the α ray amount is 0.01 (cph/cm^2) or less, if the Ag content is, for example, 3.5 wt%, a needle like projection is generated by lowering the α ray amount. In order to restrain the needle-like projection, the Ag content should be in the recited range. Again, there is no disclosure in the cited references of this phenomenon.

As can be seen from Table 1 and Table 2 of the present application, even if the α ray amount is 0.01 (cph/cm^2) or less, if Ag is less than 1.5% or greater than 2.8%, various problems arise.

Appellants again note that that Akamatsu JP '427, the only reference to discuss α rays, does not require **either** the limitation on the amount of Ag or of Sn. Clearly, the advantages resulting from the combination of limitations in the present claims are not suggested at all by Akamatsu JP '427.

Appellants therefore submit that all of the claims under appeal are novel and non-obvious over PL 115725 (Kozlowski et al.), JP 2000015476 (Matsumoto et al.), Arai et al. (1999 article), Ogashiwa et al. (U.S. Patent No. 6,160,224), and JP 409260427 (Akamatsu et al.), taken separately or in combination.

Issue B. Whether claims 15 and 16 are unpatentable under 35 U.S.C. 103(a) over PL 115725 (Kozlowski et al.), JP 2000015476 (Matsumoto et al.), Arai et al. (1999 article), or Ogashiwa et al. (U.S. Patent No. 6,160,224) in view of JP 409260427 (Akamatsu et al.), and further in view of Bult et al. (U.S. Patent No. 4,690,725).

1. The specific limitations in the rejected claims which are not described in the prior art, and how such limitations render the claimed subject matter unobvious over the prior art.

Claims 15 and 16 depend from claims 1 and 4, respectively. Accordingly, the arguments presented above with regard to the rejection of claims 1-6 are applicable here.

Appellants note that Bult et al. '725 discloses purification of Cd and Te by zone refining. The reference mentions purification of Sn in column 1, line 65, in discussion of the Background of the Invention. Appellants submit that there is no disclosure in Bult et al. directly relevant to the limitations on Ag or Sn content of alloys, or of the amount of α rays, as disclosed in claim 1. Moreover, Bult et al. does not discuss in detail the purity of Sn that can be achieved by zone refining. Applicants submit that all of the claims are novel and non-obvious over PL 115725 (Kozlowski et al.), JP 2000015476 (Matsumoto et al.), Arai et al. (1999 article), Ogashiwa et al. (U.S. Patent No. 6,160,224), JP 409260427 (Akamatsu et al.), and Bult et al. (U.S. Patent No. 4,690,725), taken separately or in combination.

In the event this paper is not timely filed, appellant hereby petitions for an appropriate extension of time. The fee for any such extension may be charged to our Deposit Account No. 01-2340, along with any other additional fees which may be required with respect to this paper.

Respectfully submitted,

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Enclosures: Appendix
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IX. APPENDIX–CLAIMS INVOLVED IN THE APPEAL

1. A semiconductor device comprising a circuit substrate, a semiconductor element, and a bump made of a solder alloy through which said semiconductor element is bonded onto said circuit substrate,

said solder alloy being an Sn-Ag-based alloy having its Sn content of 90 (wt%) or more and its Ag content within the range of 1.5 (wt%) to 2.8 (wt%), the amount of α rays in Sn being 0.01 (cph/cm^2) or less.

2. The device according to claim 1, wherein said semiconductor element is connected to said circuit substrate through 1,000 or more terminals each of which is made of a bump.

3. The device according to claim 1, wherein said solder alloy contains at least one of Cu, Zn, In, Sb, and Bi as an additive ingredient.

4. A circuit substrate comprising semiconductor elements bonded thereon through bumps made of a solder alloy,

said solder alloy being an Sn-Ag-based alloy having its Sn content of 90 (wt%) or more and its Ag content within the range of 1.5 (wt%) to 2.8 (wt%), the amount of α rays in Sn being 0.01 (cph/cm^2) or less.

5. The substrate according to claim 4, wherein each of said semiconductor elements is connected to said circuit substrate through 1,000 or more terminals each of which is made of a bump.

6. The substrate according to claim 4, wherein said solder alloy contains at least one of Cu, Zn, In, Sb, and Bi as an additive ingredient.

15. The semiconductor device of claim 1, said solder alloy being made from Sn prepared using a zone-melt method.

16. The circuit substrate of claim 4, said solder alloy being made from Sn prepared using a zone-melt method.